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Productivity and efficiency of *Aedes aegypti* (L) immature in breeding sites

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Abstract
Selection of breeding sites can influence the biological features of the mosquito and enhance the implementation of the dengue vector control. The major objective of this study was to evaluate the larval and pupal productivity and efficiency of *Aedes aegyptis*' breeding sites. Community development blocks (n=9) of the Kanyakumari district were selected as the main sampling site. In the present study 16 water- holding containers were analyzed among them the most efficient breeding sites are tyres (Le: 6.72), followed by plastic sheets and bags (Le: 6.04), and the coconut shells (Le: 5.93).

Keywords: community development blocks, *Aedes aegypti*, breeding sites, pupal productivity

1. Introduction
Mosquitoes are vital arthropod vectors involved in the transmission of pathogens of different human and vertebrate diseases. Management of mosquitoes is challenging because of their selected breeding sites, breeding techniques adopted, tolerance of desiccation and the potential to undergo egg and larval diapauses and they exists pesticide resistance. Therefore, it is arduous to eliminate mosquito populations through chemical insecticides as well as growth regulators. In the past, the most successful mosquito control strategy has been reported as larviciding. One of the other best controlling method is source reduction. For effective mosquito management, researchers have been proposed, some alternate strategies like biological control, genetic control, attract and kill methods, sterile insect technology, gene silencing and gene drives techniques.
The pathogens spread by mosquitoes are viruses and nematodes. *Aedes aegypti* (L) mosquitoes are competent vectors of several pathogens of human health importance such as chikungunya, dengue, yellow fever, and Zika viruses that causes dangerous diseases like dengue, yellow fever, and chikungunya. *Ae. aegypti* mosquitoes can undergo its immature development in natural and artificial containers. *Ae. aegypti* may prefer containers as a favourable breeding source because of conducive water quality characteristics (Paupy *et al.*, 2009) [5]. *Ae. aegypti* primarily breed in artificial water containers and its life cycles are closely related to human activities. The abundance of mosquitoes has given a negative effect on the quality of life to the human environment (Nazri *et al.*, 2013) [4]. In urban areas, mosquitoes are prone to utilize water-filled containers in the development of immature life stages.
Most of the mosquito species could prefer to oviposit in shaded areas (Dejene *et al.*, 2015) [1]. The selection of suitable breeding sites to lay eggs is basic to the distribution and establishment of *Ae. aegypti* populations. The activities like reproduction, aggregation and offspring production are controlled by chemical signals. They are identified towards the odour depending on the nature of the stimulus. Females use their olfactory sense to select a place with the nutrients necessary for the development of the larvae. This factor is essential, not just enhance the chances of survival, also in guaranteeing the emergence of many *Ae. aegypti* adults.

2. Materials and methods
2.1 Study Area
Community Development Blocks (n=9) of the Kanyakumari district were selected as the main research site to study the water quality characteristics of *Ae. aegypti* mosquitoes' breeding sites. The selected landscape characteristics of this area are the developing urban areas and rural areas. The major land-use in this area is residential and commercial.

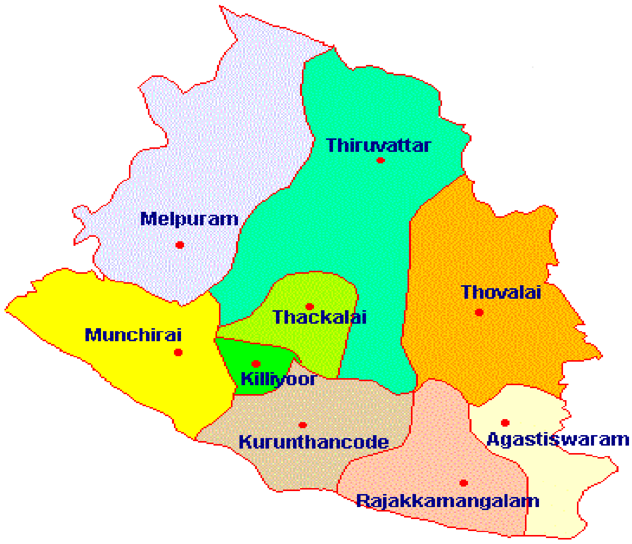

Fig 1: Map showing the location of the study area

2.2 Mosquito Sampling
The selection of the localities was based on the constant occurrence of dengue fever cases for two years (2017-2019). A peri-domestic area survey was carried out to detect mosquito larval breeding sites which reflect the infestation level with *Ae. aegypti* larvae in the localities for two years

(May 2017 – May 2019). The water-holding containers were visually inspected for the presence of water with *Ae. aegypti* immature mosquitoes such as larvae and pupae. All the water-holding containers detected during the survey were counted and classified into 16 categories based on the breeding site identity (BSID). BSID were given to the containers observed at the sampling sites were BS1: Plastic pots; BS2: Flower vases; BS 3: Buckets; BS 4: Drums; BS 5: Earthen pots; BS 6: Tires; BS 7: Coconut shells; BS 8: Plastic sheets and bags; BS 9: Water holding glass materials; BS 10: Water Reservoirs; BS 11: Discarded appliances such as discarded foams, shoes, and helmets; BS 12: Dust carriers and bins; BS13: Ant guards and trays; BS14: Group of metals; BS15: Refrigerators and BS16: Tree holes and leaves. The Specimens of immature mosquitoes were kept in plastic bottles and transported to the laboratory. The larvae and dead pupae were counted and identified to species under a compound microscope according to the standard keys.

2.3 Larval Sampling Equipment

The larvae were collected from the field to different types of containers with the help of a circular plastic net of 10 mm mesh size. Brush, glass and plastic specimen bottles (Tarsons ®TM 100 ml, 250 ml) and glass pipettes were used to handle immature and adult mosquitoes in laboratories and containers. The number of larvae and pupae were recorded along with the container types and added to a database for subsequent analyses.

2.4 Larval Identification

Larvae collected from the field were identified to determine the species. The equipment that was used for identification is the compound microscope. The identification was aided by the Pictorial Key for Identification of Mosquito by Leopoldo M. Rueda (Rueda, 2004) [6]. The larvae are divided into three main parts which are the head, thorax, and abdomen. All three parts were observed to identify the setae, the segment VIII, the siphon, and the anal segment or the segment X, which resembles the parts and segments of an *Ae. aegypti* larvae. All larvae collected were identified, and only *Ae. aegypti* mosquito larvae were being taken into count. Other mosquito larvae will be excluded. Larval and pupal productivity, prevalence, and efficiency were calculated by the given formulas, (Dom *et al.*, 2016) [3]

$$\text{Larval Productivity} = \frac{\text{No.of } Ae.aegypti \text{ larvae}}{\text{All larvae}} \times 100 \quad (1)$$

$$\text{Pupal Productivity} = \frac{\text{No.of } Ae.aegypti \text{ pupae}}{\text{All pupae}} \times 100 \quad (2)$$

$$\text{Prevalence of container} = \frac{\text{No.of positive containers}}{\text{All containers}} \times 100 \quad (3)$$

$$\text{Efficiency} = \frac{\text{Productivity}}{\text{prevalence of containers}} \times 100 \quad (4)$$

3. Results

Ae. aegypti immature mosquito samples were collected at 9 community blocks of Kanyakumari district where 3236 larvae and 1751 pupae collected. Details on sampling localities are presented in Fig. 1 Based on the result obtained, *Ae. aegypti* was identified as 10.22 % of the total mixed mosquito larvae and 10.32 % pupae.

Ae. aegypti mosquitoes breeding containers' larval productivity and efficiency, pupal productivity and efficiency were identified. The obtained results are given in Table 1 and Table 2, Fig.2 and Fig. 3 respectively. *Ae. Aegypti* mosquitoes' larval productivity and larval efficiency were observed in Plastic pots (BS1), Flower vases (BS2), Buckets (BS3), Drums (BS4), Earthen pots (BS5), Tyres (BS6), Coconut shells (BS7), Plastic sheets and bags (BS8), Water holding glass materials (BS9), Water Reservoirs (BS10), Discarded appliances (BS11), Dust carriers and bins (BS12), Ant guards and trays(BS13),Group of metals (BS14), Refrigerators(BS15), Tree holes and leaves (BS16) respectively.

The obtained L_P (Larval productivity) values of each breeding sites were 3.07, 1.19, 16.90, 4.29, 0.05, 20.58, 33.22, 13.66, 11.99, 4.84, 10.22, 3.35, 2.65, 15.35, 1.65 and 0.36 respectively. The obtained Le (Larval efficiency) values of each breeding sites were 4.65, 2.97, 3.96, 4.04, 0.02, 6.72, 5.93, 6.04, 4.73, 1.72, 2.83, 4.18, 4.01, 3.19, 3.11 and 1.38 respectively, and Pc (Prevalence of container) of each breeding sites were 0.66, 0.4, 4.26, 1.06, 2.13, 3.06, 5.6, 2.26, 2.53, 2.8, 3.6, 0.8, 0.66, 4.8, 0.53 and 0.26 respectively. The efficiency of breeding sites was calculated from productivity over prevalence of each type of breeding containers.

Ae. Aegypti mosquitoes' pupal productivity and pupal efficiency were observed in BS1, BS2, BS3, BS4, BS5, BS6, BS7, BS8, BS9, BS10, BS11, BS12, BS13, BS14, BS15 and BS16 respectively.

Table 1: *Ae. Aegypti* mosquitoes' larval productivity and efficiency in various breeding sites

BSID	No. of *Ae. aegypti* larvae	No. of total containers	No. of positive containers	Larval productivity (L_p)	Prevalence of container (P_c)	Larval efficiency (L_e)
BS1	62	750	5	3.07	0.66	4.65
BS2	24	750	3	1.19	0.4	2.97
BS3	341	750	32	16.90	4.26	3.96
BS4	87	750	8	4.29	1.06	4.04
BS5	107	750	16	0.05	2.13	0.02
BS6	518	750	23	20.58	3.06	6.72
BS7	703	750	42	33.22	5.6	5.93
BS8	277	750	17	13.66	2.26	6.04
BS9	312	750	19	11.99	2.53	4.73
BS10	97	750	21	4.84	2.8	1.72

BS11	216	750	27	10.22	3.6	2.83
BS12	74	750	6	3.35	0.8	4.18
BS13	53	750	5	2.65	0.66	4.01
BS14	325	750	36	15.35	4.8	3.19
BS15	33	750	4	1.65	0.53	3.11
BS16	7	750	2	0.36	0.26	1.38
Total	3236	12000	266	10.22	2.21	4.62

Table 2: *Ae. Aegypti* mosquitoes' pupal productivity and efficiency in various breeding sites

BSID	No. of *Ae. aegypti* larvae	No. of total containers	No. of positive containers	Pupal Productivity (P_p)	Prevalence of container (P_c)	Pupal efficiency (P_e)
BS1	43	750	5	4.27	0.66	6.46
BS2	7	750	3	0.70	0.4	1.75
BS3	152	750	32	15.15	4.26	3.55
BS4	58	750	8	5.75	1.06	5.42
BS5	84	750	16	8.27	2.13	3.88
BS6	317	750	23	22.43	3.06	7.33
BS7	502	750	42	49.26	5.6	8.79
BS8	79	750	17	7.77	2.26	3.43
BS9	115	750	19	7.65	2.53	3.02
BS10	67	750	21	6.72	2.8	2.4
BS11	96	750	27	9.48	3.6	2.63
BS12	52	750	6	5.16	0.8	6.45
BS13	38	750	5	3.85	0.66	5.83
BS14	126	750	36	12.45	4.8	2.59
BS15	11	750	4	1.03	0.53	1.94
BS16	4	750	2	0.44	0.26	1.69
Total	1751	12000	266	10.32	2.21	4.66

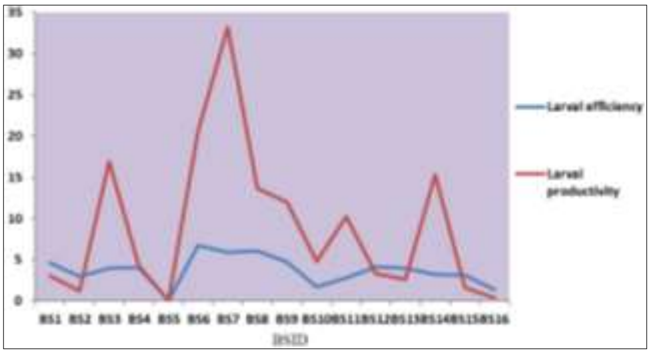

Fig 2: *Ae. aegypti* mosquitoes' larval productivity and efficiency in various breeding sites

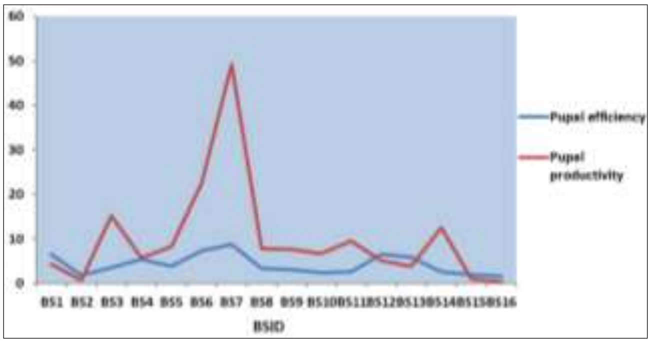

Fig 3: *Ae. Aegypti* mosquitoes' pupal productivity and efficiency in various breeding sites

The obtained pupal productivity values of each breeding sites were 4.27, 0.70, 15.15, 5.75, 8.27, 22.43, 49.26, 7.77, 7.65, 6.72, 9.48, 5.16, 3.85, 12.45, 1.03 and 0.44 respectively. The obtained pupal efficiency values of each breeding sites were 6.46, 1.75, 3.55, 5.42, 3.88, 7.33, 8.79, 3.43, 3.02, 2.4, 2.63, 6.45, 5.83, 2.59, 1.94 and 1.69 respectively. Prevalence (Pc) of each breeding container was 0.66, 0.4, 4.26, 1.06, 2.13, 3.06, 5.6, 2.26, 2.53, 2.8, 3.6, 0.8, 0.66, 4.8, 0.53 and 0.26 respectively. The efficiency of breeding sites was calculated from productivity over prevalence of each type of breeding sites.

4. Discussion

Mosquitoes select their breeding sites accordingly with their preferred characteristics that may help them to survive and for their population dynamics. Certain conditions of the site can be favoured by that several chemical properties of the larval habitat in peri domestic area are related to vegetation as well as different content of physicochemical characteristics which may affect the larval development and survival. *Ae. aegypti* prefers to lay their eggs in domestic containers with a majority of discarded receptacles, water storage containers and tyres, wells, cement tanks and sinks (Dieng *et al*., 2012) [2]. The size of the container can have different number of predators. Small container will have fewer predators or even not existed. Smaller container also creates a smaller number of preys that might be too small to support trophic levels higher than filter feeding mosquitoes in that particular habitat.

Based on the result obtained from larval productivity (Lp) and efficiency (Le) of dengue vector breeding containers, most of the *Ae. aegypti* mosquitoes prefer to breed in small containers. This finding collaborates with the study by Sunahara *et al*. (2002) [7] which highlighted that the small size of container habitat can be vital characteristics that control the community structure of mosquitoes and predator. The coexistence of *Ae. aegypti* and *Ae.s albopictus* in breeding containers is likely to attribute to the abundance of suitable container that are favorable to all containers-breeding mosquitoes and the availability of shade and sufficient organic material for larval feeding. In the present study 16 water- holding containers were analyzed among them the most efficient breeding sites are tyres (Le: 6.72), followed by plastic sheets and bags (Le: 6.04), and the coconut shells (Le: 5.93). This study correlates with the study of Dom *et al*. (2016) who determined water quality characteristics of dengue vectors breeding containers and reported that the most efficient group of water- holding containers for the development of immature dengue vectors are types of aquarium unused glass jars and ceramics (Le: 12.98), followed by tires (Le: 11.21), and the plastic sheets (Le: 7.30).

5. Conclusion

The types of mosquitoes' breeding sites, physical parameters of water, and conditions of water filled containers may reflect the oviposition preferences of carrying females of *Ae. aegypti*. Selection of breeding sites is a vital factor for its survival in natural and artificial settings. These factors indirectly play critical implication for the mosquito control programme. Therefore, knowledge in aquatic habitat selection for breeding of dengue vector mosquitoes is essential in order to implement a sustainable mosquito control.

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